

GROWTH AND CHARACTERIZATION OF CdTe NANOSTRUCTURES GROWN BY CHEMICAL REDUCTION ROUTE

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ABSTRACT

CdTe nano particles are grown by varying temperature and keeping ratio of reagent constant. The samples are characterized structurally and optically. An increase in band gap is observed compared to bulk CdTe in each growth condition. Also the nanorods formation is found to be favourable at particular temperature. An attempt is made to correlate the structural and optical properties.

KEYWORDS: Synthesis of Nanomaterials, Structural Properties, Optical Properties

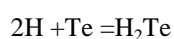
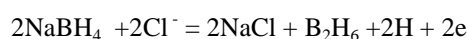
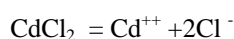
INTRODUCTION

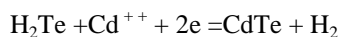
Semiconductor nanoparticles, which exhibit properties different from bulk materials, are a new class of materials that hold considerable promise for numerous applications in the field of electronics and photonics. Nanoscale modification of the molecular design and morphology of such particles provides a powerful approach toward control of their electrical and optical properties [1-4]. Among the colloidal nanocrystals, CdTe (generally Gr-II to Gr-VI) is studied because of the efficiency of its synthesis, the high quality of the resulting sample, and the fact that the optical gap lies in the visible range. Also it is an important semiconducting material with unique electrical properties, which makes it a promising material in the field of opto-electronic devices such as Light Emitting Diodes, Solar Cells, Photo Detectors, Biosensors, etc[5-6]. There are various methods of the preparation of CdTe nanoparticles. Some of the above mentioned methods have some drawbacks. Used precursors are unstable, are an environmental hazard, and require very high temperatures. These methods are not cost effective either. Hence a simple chemical reduction route has been preferred. The grown sample is characterized structurally, optically by varying the growth temperature.

EXPERIMENTAL SECTION

Anhydrous CdCl₂(molecular weight-201.32gm/mole) (603.96 mg),Tellurium (molecular weight-127.6gm/mole) (382.8 mg) powder and sodium borohydride (molecular weight-37.83gm/mole) (113.49 mg)have been taken to prepare different samples. Ethylenediamine has been used as a capping agent. Sodium borohydride has been taken to initiate the reaction at room temperature as well as higher temperatures.

In order to prepare different samples, the amounts of CdCl₂, Te and NaBH₄ were taken in the ratios of 1:1:1 for different temperatures (room temperature, 318K and 333K) . The stirring was continued for 3 hours at a particular speed. The reactions are as follows.





The grown sample is filtered. The sample on the filter paper is washed using doubly ionized water. The sample is then dried and finally collected. As for TEM measurements, the as-prepared CdTe nanoparticles have been dispersed in Toluene by ultrasonification. A small drop of dispersed CdTe nanoparticle has been taken on a thin carbon film supported on the copper grid and kept for some time for drying. The Transmission Electron Micro-graph of the as-prepared samples has been taken using a JEOL-JEM-200 transmission electron microscope operating at 200 kV. SAED pattern and EDX analysis of the said nanoparticle were also performed. Optical absorption measurements of the dispersed samples have been studied in the range of 280 nm–700 nm using a Shimadzu Pharmaspec 1700 UV–VIS Spectrophotometer. Photoluminescence studies of the dispersed samples have been studied using Perkin Elmer LS55 Fluorescence spectrometer.

RESULTS AND DISCUSSIONS

Structural Determination (XRD)

The powder X-ray diffraction (XRD) pattern on the samples were recorded by a X-ray diffractometer (miniflex II, desktop-X-ray diffractometer) using Cu- $\text{k}\alpha$ radiation of wave length $\lambda = 1.54 \text{ \AA}$ for 2θ ranging from 20° to 70° . Figure-I shows the XRD patterns of these samples. Cubic phase predominates in the grown sample. With increase of growth temperature, peak intensity increases.

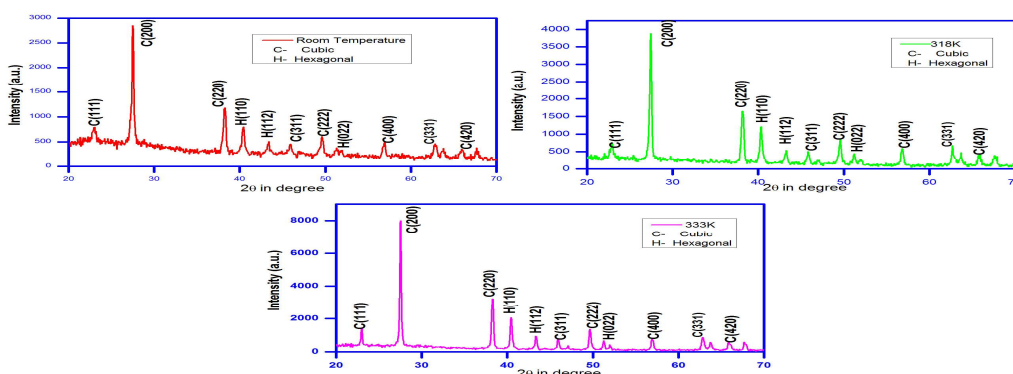


Figure 1: The XRD pattern of CdTe- nanostructures

Morphological Study (TEM)

Morphologies of the products synthesized at fixed reactional time at molar concentration for different temperatures are shown in figure 2-4. The diameter of the nanoparticles is in the order of 8nm to 12nm (Approximately). CdTe nanoparticles change to nanorods and finally agglomerated with increase of growth temperature. Single crystallinity increases with increase of growth temperature.

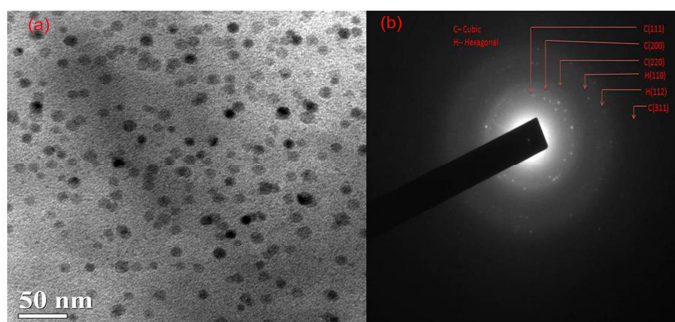


Figure 2: (a) HRTEM image and (b) SAED pattern of CdTe grown at room temperature

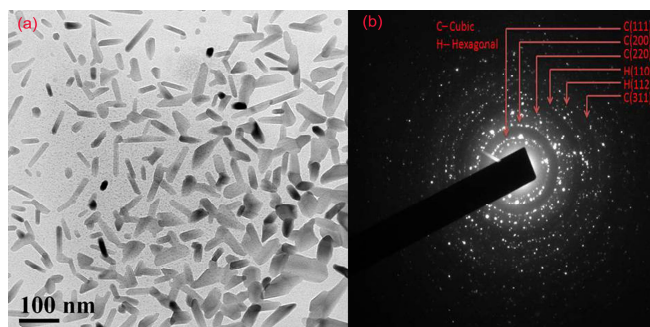


Figure 3: (a) HRTEM image and (b) SAED pattern of CdTe grown at 318K

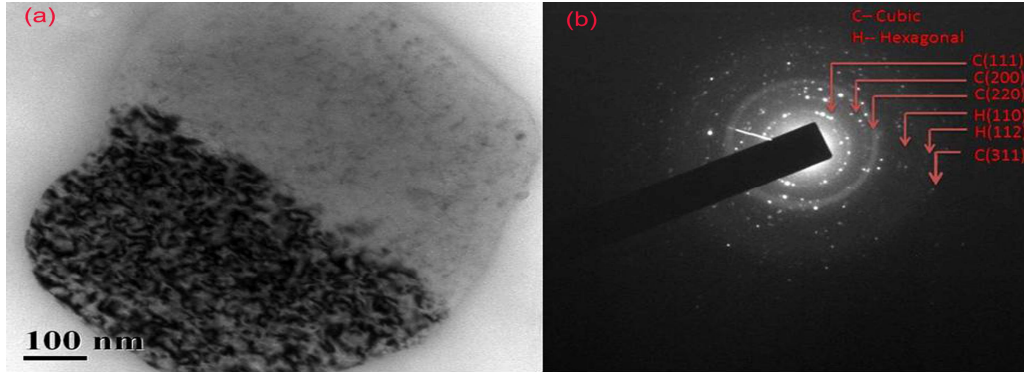


Figure 4. (a) HRTEM image and (b) SAED pattern of CdTe grown at 333K

Optical Properties of CdTe – Nanostructure

Optical properties of CdTe samples were determined through UV-VIS absorbance spectroscopy and photoluminescence studies. CdTe nanoparticles were dispersed in spectroscopic grade Toluene for UV-VIS absorption measurements.

Figure – 5 shows the optical absorbance spectra of CdTe samples grown at different temperatures. Optical absorption coefficient has been calculated in the wavelength region of 280-700 nm. Figure -6 shows the plot of $(\alpha h\nu)^2$ vs. energy ($h\nu$) and it is used to determine band gap. The band gap of the as- prepared nanostructures is determined from the relation $(\alpha h\nu) = C (h\nu - \Delta E_g)^{1/2}$ where C is a constant.

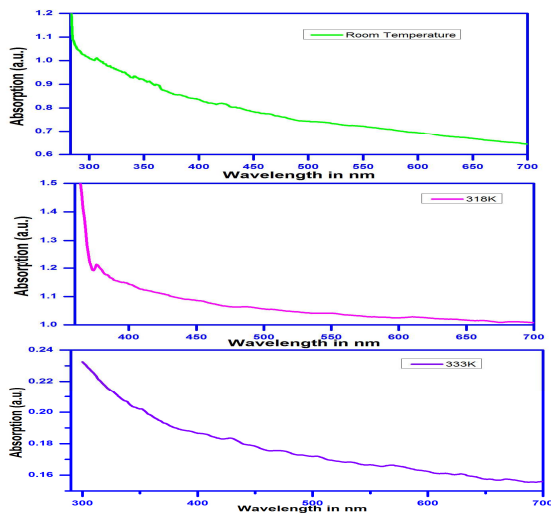


Figure-5 Optical absorption spectra of as prepared samples dispersed in Toluene

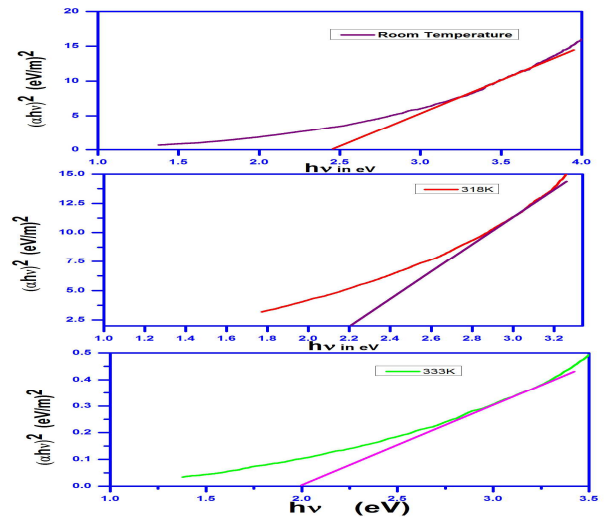


Figure 6: plot of $(\alpha h\nu)^2$ vs. $(h\nu)$ to determine band gap in each case

PHOTOLUMINESCENCE

The PL spectra of the CdTe sample products were measured with excitation wavelength 360 nm. Figure-7 shows PL spectra of the CdTe samples prepared at different temperatures. PL peak shifts slightly towards higher wavelength with increase of temperature.

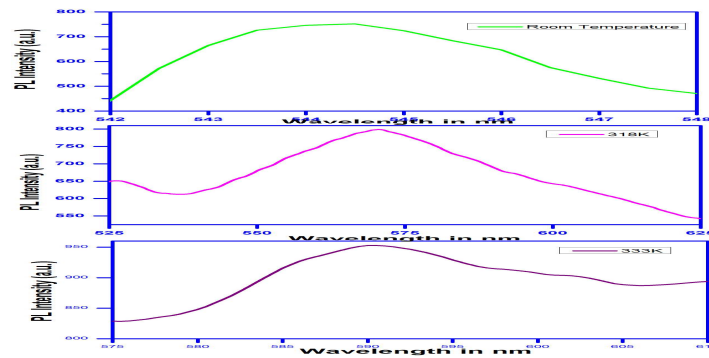


Figure 7: Photoluminescence spectra of as prepared samples

Comparison Table

Table 1: Summarisation Table

Name of Samples	Growth Temp.	Shape of Nanostructure	Size of the Nanostructure (nm)	Band Gap (eV)
CdTe -1	300K	Spherical nanoparticles	Diameter-10	2.46
CdTe -2	318K	Nanorod	Nanorods length- 45 , diameter- 10	2.20
CdTe -3	333K	Agglomerated nanorods	Nanorods length- 55 , diameter- 15	2.01

CONCLUSIONS

CdTe nanoparticles are formed at room temperature while nanorods are formed at higher growth temperature. At higher temperature there is a tendency of agglomeration of the nanorods. It can be clearly observed that the size and shape of CdTe nanoparticles generally depend on the growth temperature. Optical absorption study shows that with increase of temperature the band gap shifts towards lower energy value. This clearly indicates that with formation of nanorods at higher temperature the quantum confinement is reduced. The synthesis route is easily controllable and reproducible.

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